

On the Interoperability of eBook Formats

Prof. Christoph Bläsi

Prof. Franz Rothlauf

Johannes Gutenberg-Universität Mainz – Germany

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Prof. Christoph Bläsi | Prof. Franz Rothlauf

Professor of Book Studies | Professor of Information Systems
Johannes Gutenberg-Universität Mainz – Germany

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European and International Booksellers Federation
rue de la Science 10 – 1000 Brussels – Belgium
www.europeanbooksellers.eu – www.ibf-booksellers.org
info@europeanbooksellers.eu

Message from
Madam Neelie Kroes
Vice-President of the European Commission

NEELIE KROES
VICE-PRESIDENT OF THE EUROPEAN COMMISSION

It is no secret that Europeans like reading. They like reading printed books, but increasingly ebooks too. And it is a well-known challenge that bookshops have to re-invent themselves for the digital world. Booksellers play an important role in our European societies. They are a little like friends recommending a good book for you and helping you discover your own taste and have a good time reading it. They also offer a nice social space where you can find inspiration and peace in your busy life schedule.

My wish is that booksellers in Europe can take initiatives and benefit from the growth in the ebook markets. This is why I also welcome this study by the European Booksellers Federation. Interoperability is a major requirement to build a truly digital society. This applies to ebooks too. When you buy a printed book it's yours to take where you like. It should be the same with an ebook. You can now open a document on different computers, so why not an ebook on different platforms and in different apps? One should be able to read one's ebook anywhere, any time on any device.

This study provides interesting insights on ways to reach true interoperability in the ebook market, through both interoperable ebook formats and interoperable DRM schemes. Now is the time for open standards regarding ebooks, just like has happened in other areas of the digital economy.



Neelie Kroes
Vice-President of the European Commission,
in charge of the Digital Agenda

Foreword

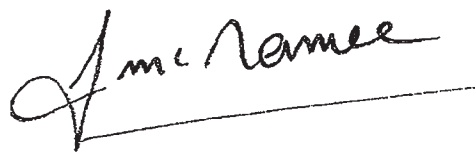
The European Booksellers Federation has been fully supportive of the political objectives of the Digital Agenda promoted by the European Commission since its launch.

Booksellers across Europe are fully engaged in developing and implementing the new business models that are opening up as a result of the digitization of books and reading. They are keen to meet the expectations of digital readers, as long as copyright, fair business models and independence of choice are respected.

The lack of interoperability between formats and platforms has been identified as one of the major obstacles hindering the Digital Agenda. On behalf of my colleagues from all Booksellers Associations in membership with EBF, I am very pleased that this study provides clear scientific evidence that interoperability is achievable. It also shows that there are alternatives to DRM's and that content portability is feasible. Booksellers are keen to promote business models which make digital content easily accessible to the customers they are in touch with on a daily basis in their terrestrial or e-bookshops, the European readers.

Equally, booksellers are keen to sell e-books across borders and make as many customers as possible happy. They strongly support an open market, without territorial restrictions, in the full respect of copyright.

It is crucial to preserve a healthy book chain in Europe, as writers, publishers and booksellers are essential in promoting cultural diversity and high quality content. It is therefore of paramount importance to promote fair and sustainable business models and an even playing field for all book retailers in the book industry, and ultimately for the benefit of all European readers.

A handwritten signature in black ink, reading "John Mc Namee". The signature is written in a cursive style with a long horizontal line extending from the end of the name.

John Mc Namee
President

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Executive Summary

It is widely seen as a serious problem that European as well as international customers who have bought an ebook from one of the international ebook retailers implicitly subscribe to this retailer as their sole future ebook supplier, i.e. in effect, they forego buying future ebooks from any other supplier. In particular, this is a threat to the tight and qualified European book distribution infrastructure and hence to the European book culture, since subscribers to one of these ebook ecosystems cannot buy future ebooks from privately owned community-located brick & mortar booksellers engaging in ebook retailing. This view is completely in line with the European Commission: the Digital Agenda of the European Commission calls in pillar II (interoperability and standards) for an “effective interoperability between IT products and services to build a truly digital society. Europe must ensure that new IT devices, applications, data repositories and services interact seamlessly anywhere – just like the Internet.”

It is the task of this report to study whether convincing technological or functional reasons on the side of the international ebook retailers can be identified to justify non-interoperable ebook formats. Moreover, we study the digital rights management (DRM) measures employed by those retailers and question the necessity to build up additional walls between the ecosystems with the help of such measures. In the process, we will also address the challenge to protect intellectual property adequately across ebook ecosystems. And we evaluate the potential of the proposal for a common ebook format standard covering multimedia and interactivity features, EPUB 3 (as proposed by the IDPF in October 2011), and also dwell on interoperable options regarding the DRM protection of intellectual property.

Major players in the ebook market, especially Amazon or Apple, have built up closed ebook ecosystems in the last few years. eBooks that are distributed via one of these ecosystems are formatted using ecosystem-specific ebook formats like KF8 (Amazon) or Fixed Layout EPUB/.ibooks (Apple). As well as using incompatible ebook formats, Apple and Amazon fence their ecosystems with the help of DRM measures of various kinds. These measures prohibit the export and import of files to and from other ecosystems. Some of these measures are restrictive software-based methods using encryption. Thus, ebooks can only be read on ecosystem-specific end-user devices (or reader applications) such as the Kindle readers (in the case of the Amazon ecosystem) or iPads or iBooks (for the Apple ecosystem). The transfer of ebooks from one ecosystem into another is not possible (or, at least, requires measures that are not legal).

The main results of our study are the following:

1. **eBook Formats:** Having gone through the features of the different ebook formats (EPUB 3, KF8, Fixed Layout EPUB, and .ibooks) from page layout aesthetics to multimedia and interactivity, we conclude that EPUB 3 clearly covers the superset of the expressive abilities of all the formats.

Therefore, we cannot see a technological or functional reason to go on using proprietary ebook formats. A possible move from proprietary ebook formats to EPUB 3 on the side of Amazon and Apple would be facilitated by the fact that all formats have a common predecessor, namely EPUB 2 (from 2007 on). KF8, Fixed Layout EPUB, and .ibooks do not only share the underlying basic concepts for ebook production and distribution with EPUB 3, but also parts of the data structures. Moreover, Apple was actively engaged in the definition of the EPUB 3 standard; with Amazon's KF8, it can be observed that more recent versions converge with EPUB 3 with respect to a growing number of features.

2. **Digital Rights Management Measures:** The general use of EPUB 3 as an interoperable ebook format would not in itself lead to full interoperability of ebooks for customers. The reason for that is that Apple and Amazon additionally fence their ecosystems with the help of DRM measures of different types and robustness. To overcome some of these obstacles to full interoperability, unilateral decisions of the enterprises in question would suffice, e.g. by offering data file import and export on the interfaces of their reader applications. For others – software-based methods using encryption, mostly at the request of the copyright holders – more fundamental measures would have to be taken, including multi-lateral agreements on using compatible or identical encryption solutions, e.g. open (source) solutions.

To sum up, there is no technical or functional reason not to use and establish EPUB 3 as an/the interoperable (open) ebook format standard. One short-term obstacle is the non-availability of reader applications able to display all EPUB 3 features. However, this problem should be fixed soon by the IDPF Radium initiative which is developing an open source reference system and rendering engine for EPUB 3. Given the will to do so on the side of Amazon and Apple, the DRM barrier between the ecosystems could be partly overcome by simple changes to the respective store and reader applications, and partly only by more demanding agreements between different players on interoperable DRM solutions. The latter is only necessary if copyright holders continue insisting on having their intellectual property protected by highly restrictive measures.

1 Introduction

Major players in the ebook market like Amazon or Apple have built up closed ecosystems for ebooks in the last few years. In such closed ecosystems, readers can import ebooks or buy ebooks from the ebook stores available, but no platform-independent use or reading of ebooks is possible, as it is impossible or at least difficult to export ebooks. As well as the impossibility of exporting ebooks, other instruments for building up closed ecosystems are a tight coupling between reading devices and the store, proprietary digital rights management (DRM) protection, and/or the use of proprietary and incompatible ebook formats. Examples of ecosystem-specific ebook formats are KF8 by Amazon or Fixed Layout EPUB and .ibooks by Apple.

Non-interoperable ebook formats cause various problems for customers as the making available and reading of ebooks becomes ecosystem-specific. For example, ebooks that are provided by Amazon can only be read and used on Amazon devices (and reading apps); analogously, reading an ebook from Apple's iBookstore on Amazon's Kindle reader is impossible due to the non-interoperability of the formats. The transfer of ebooks from one ecosystem into another is not possible (or, at least, requires illegal measures) for customers. Therefore, buying books in different ecosystems and viewing them with the same reader becomes impossible. The existence of closed ecosystems in the ebook market also causes problems for local bookstores and other online retailers which deliver ebooks using interoperable formats. Customers with Amazon's Kindle readers can only read ebooks bought from the Amazon Kindle Store. Therefore, not only is there no free choice of online bookseller, but it is impossible to buy ebooks at local bookstores or other online retailers as the Kindle reader can only process ebooks in Amazon's KF8 format, which cannot be provided by the local bookseller or other online retailers.

Besides incompatible formats, ebook resellers use proprietary DRM measures to prohibit the free exchange of ebooks between different ecosystems and to protect their own ecosystem. Therefore, ecosystem-specific and proprietary DRM measures have the same function as incompatible book formats as they restrict the access to book content to customers of one ecosystem. Given his/her specific device, a customer can only buy ebooks that are available in the ecosystem to which his/her end-user device belongs. For example, although Apple uses an interoperable ebook format (EPUB) for some of its content, the owner of an Apple reading device (e.g. iPad) cannot transfer his/her DRM-protected ebooks from his/her reading device to a non-Apple reading device, as Apple's DRM system (Apple FairPlay) is proprietary and does not allow the export of ebooks.

The existence of closed ecosystems is also an obstacle to the accessibility of ebooks. As the content available in a particular ecosystem is only a subset of all available books, accessibility is limited to those books that are offered in the ecosystem to which a particular reader belongs. eBooks that are only

available in other ecosystems are not accessible by a reader. This is especially the case for self-published books as the terms of use of some ebook stores (e.g. Amazon's Kindle Direct Publishing Program) explicitly forbid an author to offer his/her book at a different store for a limited period of time. A comparison of the Amazon and Apple ebook stores reveals that Amazon offers more ebooks than Apple, and the average prices of ebooks offered in the Amazon Kindle Store are lower than in the Apple iBookstore. The price difference illustrates the different choices offered by the two ebook stores. The higher price is a result of Apple's strict control of the ebooks offered in its store and its stronger focus on high-quality and graphic-oriented ebooks. The incompatibility of the ecosystems limits the choice of ebooks for readers, who have only the portfolio of the ecosystems to which their reader belongs at their disposal.

The European Union is aware of the problems arising from the non-interoperability of formats. In pillar II of the Digital Agenda (interoperability and standards), the European Commission calls for an "effective interoperability between IT products and services to build a truly digital society. Europe must ensure that new IT devices, applications, data repositories and services interact seamlessly anywhere – just like the Internet."

The goal of this study is to examine the technical and functional possibilities of an interoperable "cross-ecosystem" ebook format. An obvious candidate for such an interoperable format is EPUB 3, as proposed by the International Digital Publishing Forum (IDPF) in October 2011. However, to reach true interoperability in the ebook market, interoperable ebook formats are not enough: the technical DRM measures used by the retailers must also be interoperable. DRM becomes relevant if players in the bookmarket (typically publishers) want to protect their content using organisational or technical measures. With this in mind, we examine whether the DRM schemes used in the different ecosystems allow for interoperability. To reach true interoperability in the ebook market, interoperable ebook formats and interoperable DRM schemes are necessary.

Our definition of interoperability is that ebooks bought via different channels or in different ecosystems can be read using the same reader software or application, including using its administration and social reading functionalities. Interoperability does not occur if the reading of different books requires the use of different reader applications, even if they run on the same (hardware) device. Likewise, interoperability is not fulfilled if conversion tools allow authors to cross-publish ebooks in different ecosystems. For example, Amazon's KindleGen software converts EPUB ebooks into Amazon's KF8 format. The result is two different ebooks that can be distributed in different ecosystems. Moreover, this option only applies to EPUB ebooks with features that are also supported by KF8. This is a serious restriction, since EPUB 3 provides more features to the author than KF8.

The document starts with an overview of the development of the open EPUB standard. In Sect. 3, we give details on the EPUB format as well as on other relevant formats developed by Apple (.ibooks and Apple Fixed Layout EPUB) and Amazon (KF8). We chose Apple and Amazon as these are the major players in the ebook market using proprietary book formats. In Sect. 4, we study and compare the different features of the formats, looking at core features, multimedia and interactivity, and globalisation and accessibility. Sect. 6 gives an overview of different DRM mechanisms for ebooks. The final Sect. 7 presents our conclusions regarding the possibility of an interoperable ebook format, as well as the options of protecting copyrighted content with adequate measures in an interoperable scenario like this.

2 Development of EPUB

This section gives a brief outline of the development of the EPUB standard. Other competing standards like KF8 and .ibooks are discussed in Sects. 3.2 and 3.3.

The standardization of ebook formats goes back to 1998, when the Open Ebook Authoring Group was founded during the very first conference dedicated to ebooks, organized by the National Institute of Standards and Technology. The goal of this working group was to develop an open industry ebook standard based on XML, which would allow the platform-independent use of ebooks. Platform-independence became a relevant issue as the reference standard PDF was a good choice for displaying ebooks on desktop computers. However, it was inappropriate for displaying ebooks on mobile handhelds like Palm or Blackberry which became popular at the end of the 90s. Such devices have small displays of varying size and much lower computing power and memory. Consequently, the new ebook standard should have been platform-independent, reflected established content format standards, and served as a reference for content providers and device manufacturers. In 1998, the working group started with 25 members ranging from producers of handhelds and computers to large IT companies like Microsoft, Adobe and Nokia. In 1999, the working group was renamed in “Open eBook Forum”¹. The first product of the working group was the Open eBook Publication Structure (OEBPS or OeB) 1.0, which was released in 1999. Revisions of the standard were published in June 2001 as version 1.0.1 and, with only minor changes, in August 2002 as version 1.2. This version of the standard already allowed a separation of content and layout by the use of cascading style sheets (CSS).

In 2005, the Open eBook Forum changed its name to “International Digital Publishing Forum” (IDPF). The motivation for the change was the growing and changing ebook market with new players like libraries, publishers, or booksellers and the need for a support of various business models. A major problem of OEBPS 1.2 was the missing support of distribution and interaction with end-users. The 1.2 standard specified the input format for ebooks, but all output formats which are used for the delivery of the books to the customer were proprietary. Len Kawell, president of Glassbook, a company which was purchased by Adobe in 2000, already complained in 1999 that “the OEBPS 1.0 standard only covers the format of the content, not a copyright protection and distribution specification. Thus, Glassbook [like other companies] was working on an own standard [EBX] covering this area” [15]. Most of these proprietary early ebook standards used OEBPS (version 1.0 with minor changes) on the production side, however, they extended the standard on the distribution side with functionalities like compression or proprietary binary codes. Other examples for distribution extensions of the

¹ In 2013, the working group is still active in the development of open ebook standards with more than 170 members including booksellers and publishers like Random House USA, Holtzbrinck (USA), and Barnes & Noble, but also IT companies like Apple or Sony [12].

OEBPS are the LIT format developed by Microsoft or the MOBI format from the French company Mobipocket SA (Sect. 3.3). However, these proprietary extensions and developments were not in line with the goal of the IDPF, which wanted to define a standard covering all areas ranging from the production and distribution to the end customer. Thus, in 2005, the IDPF founded a working group named OEBPS Container Format Working Group to develop a container format that was able to bundle the ebook files in such a way that was also appropriate for distribution.

An important stage of the development was reached in September 2007, when EPUB 2.0 became the official standard of the IDPF and replaced the older OEBPS 1.2. A maintenance update (EPUB 2.0.1) was published in September 2010. EPUB 2.0.1 consists of three parts:

- the Open Publication Structure (OPS) 2.0.1, which describes the formatting of the content,
- the Open Packaging Format (OPF) 2.0.1, which defines the structure of the XML document, and
- the Open Container Format (OCF) 2.0.1, which compresses the files as a ZIP archive.

In contrast to OEBPS 1.2, which uses only a subset of XHTML², OPS 2.0.1 uses XHTML 1.1 for defining the text and structure of the content³. For layout and design, OPS 2.0.1 uses a subset of CSS 2.0 combined with some book-specific extensions. Furthermore, it supports vector graphics like PNG, JPEG, GIF, or SVG. The OPF 2.0.1 part defines the book metadata, the file manifest (list of all files), and the linear reading order (specified in an XML file with the .opf extension). In addition, it specifies the hierarchical table of contents in an XML file with the .ncx extension. Finally, OCF 2.0.1 defines how the files and directory structure defined by OPS and OPF are compressed in a single ZIP file with the extension .pub.

As EPUB 2.0.1 was designed for text-centric books, a variable-width layout is the only option for the display of an ebook. A variable-width layout adapts the appearance of the book to the size of the screen, allowing the reader to view an ebook on a variety of different end-user devices with different screen sizes. EPUB 2.0.1 did not allow publishers to design ebooks with fixed-width layout, which should look exactly the same on different devices. Fixed layouts are important for graphic-centered books like cookbooks or children's books. Furthermore, EPUB 2.0.1 lacked any specifications for annotations and linking in ebooks. Thus, the usage of ebooks in an educational context was difficult as interaction between different readers or between readers and publisher was limited.

The drawbacks of EPUB 2.0.1 (only limited support of multimedia and interactivity) have been addressed by the EPUB 3 specification, which was approved

² XHTML is the XML version of HTML.

³ In addition, OPS 2.0.1 also allows the use of the DTBook format, which is an XML standard designed for the needs of visually impaired people.

as an official IDPF standard in October 2011. In March 2013, the International Publishers Association (IPA) recognized EPUB 3 as the preferred standard format and recommended that publishers should use this standard for ebooks. EPUB 3 consists of four specifications:

- EPUB Publications 3.0, which defines the semantics and overarching conformance requirements for EPUB publications,
- EPUB Content Documents 3.0, which defines the formatting of content,
- EPUB Open Container Format (OCF) 3.0, which defines a file format and the wrapping into a ZIP Container, and
- EPUB Media Overlays 3.0, which defines a format and a processing model for synchronization of text and audio.

For a detailed description of EPUB 3, we refer to Sect. 3.1.

3 eBook Formats

All current major ebook formats are descendants of the earlier standards OEBPS or EPUB 2.0.1; this is obviously true for EPUB 3, but also for Amazon's KF8 format (Sect. 3.3), which was announced in 2011 with the release of the Kindle Fire. The KF8 format is based on the proprietary AZW format, which is a compressed Mobipocket format. The Mobipocket format itself is based on OEBPS combined with XHTML, JavaScript, and Frames. It was developed by the French company Mobipocket SA, which was purchased by Amazon in 2005.

The formats used by Apple also originate from the earlier EPUB standards. However, Apple's developments of its own proprietary formats (Apple Fixed Layout EPUB and .ibooks; see Sect. 3.2) were mainly motivated by the deficits of the EPUB 2.0.1 standard. Consequently, Apple was actively engaged in the definition of the EPUB 3 standard and all relevant features of Apple Fixed Layout EPUB and .ibooks can also be found in EPUB 3. For example, the underlying basic concepts for ebook production and distribution as well as large parts of the used data structures are similar or identical [11, 17].

The following sections give a brief overview of the major ebook formats and standards. In particular, we focus on the open EPUB 3 standard and the proprietary .ibooks (Apple), Apple Fixed Layout EPUB (Apple), and KF8 (Amazon) formats.

3.1 EPUB 3

The technologies used in EPUB 2.0.1 (HTML4 and CSS2) allow authors to publish text-heavy publications as ebooks. However, the creation of multimedia or interactive ebooks was very limited. These deficits are addressed by EPUB 3, which is based on HTML5 and CSS3 allowing the creation of multimedia ebooks, books with complex layout, mathematical formulae, and interactive features. EPUB 3 also introduces functionalities like fixed layout, non-linear documents, or text-to-speech. Different from EPUB 2.0.1, the new standard also allows authors to use scripting languages like JavaScript, which makes ebooks more interactive and more like programs than static books.

EPUB 3 heavily relies on HTML5 and XHTML5, respectively. HTML is the core technology for all current websites with HTML 2.0 standardized almost 20 years ago in 1995. The new standard HTML5 replaced the older HTML 4.01 specification from 1999. XHTML1 (published in 2002) and its successor XHTML5 (published along with HTML5), are the XML variants of the corresponding HTML 4.01 and HTML5 specifications. Different from HTML, which uses a markup language for describing documents, the XHTML specifications describe web documents using an XML syntax. Using the XML specification, XHTML makes the automated processing of documents easier. As of December 2012, HTML5 became a W3C Candidate

Recommendation; the W3C is planning to release a stable HTML5 recommendation by the end of 2014. Although the standardization process of HTML5 is not yet finished, most parts of the specification are stable and all relevant web browsers and many ebook viewers have already implemented large parts of the standard.

The stronger capabilities of EPUB 3 in comparison to EPUB 2 mainly come from the use of HTML5 and CSS3. Highlights of HTML5 are new elements like audio, video, canvas (drawing on the fly), the inline use of scalable vector graphics and mathematical expressions (MathML), new types of form controls, and the removal of many deprecated elements. This leads to the following new features of EPUB 3 [7]:

- The required schema for EPUB 3 content documents changed from XHTML 1.1 to XHTML5⁴. With this version change, ebooks can contain videos and audios as well as graphics, which can be drawn on the fly using JavaScript.
- EPUB 3 uses a large set of modules from CSS3, instead of only CSS 2.1 as in EPUB 2.0.1. CSS is used for describing the format and appearance of an ebook.
- Interactivity in ebooks becomes possible by the use of JavaScript.
- The addition of MathML to HTML5 allows the usage of mathematical expressions in ebooks.
- Scalable vector graphics, which can be easily adjusted to different sizes and resolutions of end-user devices, became a standard content type.
- All EPUB 3 viewers must support and show embedded fonts. EPUB 3 also supports non-Western writing modes and scripts, including vertical layout in Japanese and other Asian scripts.
- The new specification EPUB Media Overlays 3.0 allows synchronized audio narration. Media overlay documents define the timing for the pre-recorded audio narration and how it relates to the EPUB Content Document markup.

With EPUB 3, the use of audio and video files is possible using the HTML5 elements `<audio>` and `<video>`. Although different audio and video formats are specified, not all reading devices support all possible formats. Thus, EPUB 3 defines core media types which must be supported by all EPUB 3 compatible reading devices and software readers. Standards for audio are mp3 and AAC LC in mp4 containers; for video, H.264 and WebM are suggested formats.

The HTML5 element `<script>` allows authors to use JavaScript in ebooks. By using JavaScript, dynamic elements like pop-ups or animations as well as interactive elements such as forms become possible. In combination with

⁴ XHTML5 is the XML variant of HTML5.

the HTML5 element `<aside>`, the text flow can become non-linear which is an interesting option for side notes, footnotes, or pop-ups. Although EPUB 3 allows the use of scripting, it does not standardize (in relation to the core media types for multimedia content) the use of JavaScript elements in ebooks. The missing recommendation can easily lead to proprietary extensions as well as incompatible EPUB 3 readers that support a different or incompatible subset of scripting elements.

HTML5 allows authors to introduce new forms of interaction. For example, forms allow publishers to establish a feedback channel for their customers. If the end-user device has a GPS receiver or similar location device (which is, for example, the case for many mobile phones), the geographic position of the reader can be used for location-aware services. Another element `<canvas>` can be used for drawing on the fly animations like bitmaps or vector graphics as well as movies on a separate pane. Like video and audio, this powerful feature of EPUB 3 is not relevant for digital-ink readers (e.g. the majority of Kindle readers), as such end-user devices are not able to show animated graphics or movies.

In EPUB 2.0.1, OPF 2.0.1 specified the hierarchical table of contents in an XML file with the `.ncx` extension. However, this standard was not very reader-friendly and difficult to use. Thus, EPUB 3 dropped this specification and uses instead the HTML5 element `<nav>` not only for navigation and the table of contents, but also for lists of tables and lists of figures. Lists defined using `<nav>` are easier to read and interpret by humans.

For layout and design, the EPUB Content Documents 3.0 specification fully supports CSS 2.1 (same as EPUB 2.0.1) and also some additional elements of CSS3. New modules defined by CSS3 and supported by EPUB 3 are the Speech Module⁵ and Media Queries⁶. The Speech Module enables authors to control the rendering of documents via speech synthesis and provides additional text-to-speech enhancement functionalities. For example, it allows a reader to control the speech pitch and rate, sound levels, or text-to-speech voices. These stylesheet properties can be used together with visual properties (mixed media as defined in EPUB Media Overlays 3.0), or as a complete aural alternative to a visual presentation. CSS Media Queries allow authors to define different blocks of CSS code for different screen sizes. Thus, ebook content can be properly presented on end-user devices with different resolutions. Examples are the presentation of side notes next to the regular text on large displays (similar to printed books) versus their integration into the regular text using separate boxes on small displays like mobile phones. For digital-ink displays, additional boxes can be drawn around the side notes as such displays cannot display different colours, but only black and white.

Since March 2012, EPUB 3 has included a fixed-layout option for ebooks. This feature allows authors to define a static format for ebooks, which does

⁵ <http://www.w3.org/TR/css3-speech/>

⁶ <http://www.w3.org/TR/css3-mediaqueries>

not adjust to the dimensions of the end-user device. This mechanism to express the intended rendering dimensions of an ebook is essential for the design of graphic-oriented ebooks like children's books or, in general, books in which content and design are so intertwined they cannot be separated. The use of different but connected layers for graphics and underlying text still makes Fixed Layout ebooks full text searchable and allows readers to make use of the text-to-speech functionalities provided by EPUB 3.

Although EPUB 3 includes all features that allow the creation of enhanced ebooks with interactive and multimedia content, not all booksellers immediately used EPUB 3 as the distribution format for their books. An obstacle to the use of the new EPUB 3 standard has been the absence of a fully EPUB 3-compatible ebook reader. Thus, in February 2012 the IDPF together with the Open Source project WebKit (which is a widely used open source HTML5 rendering engine) and other partners like Adobe, Google, Barnes & Noble, Kobo, O'Reilly, Samsung and Sony started to develop Radium⁷, an open source reference system and rendering engine for EPUB 3. The goal of the project is to build a reference system for rendering EPUB 3 publications, which can easily be used by different ebook readers. Currently, the core EPUB 3 features are supported, while some others like Media Overlays or text-to-speech are still missing⁸. Stable releases of Radium are currently available for Google's Chrome browser. Other (proprietary) readers that support parts of the EPUB 3 standard are available from Apple, whose iBooks reading software (Sect. 3.2) supports large parts of the EPUB 3 standard, or from Ingram's VitalSource Bookshelf platform⁹ (who had already claimed in 2012 that its software reader, which is available for all major platforms, fully supports EPUB 3). We expect that the majority of ebook retailers will have their e-reading software fully support EPUB 3 by the end of 2013. This is, for example, the case with the ebook retailer Kobo, who plan to fully support EPUB 3 by the third quarter of 2013¹⁰.

3.2 Apple's eBook Formats

In January 2010, Apple announced the iPad together with iBooks, which is an application for viewing EPUB (version 2.0.1) and PDF ebooks on Apple devices. In April 2010, iBooks 1.1 became available for the iPhone and iPod Touch running iOS 4. Six months later in December 2010, Apple released iBooks 1.2 including a new format, the Apple Fixed Layout EPUB (Sect. 3.2.1). Like the fixed-layout feature of EPUB 3 (introduced in March 2012), this feature allows the creation of ebooks where content and layout cannot be separated. Typical examples are cookbooks, travel books, photography books, or children's books. The Apple Fixed Layout EPUB format is available for iPad, iPhone, and iPod Touch running Apple's iOS 4 or later.

⁷ <http://www.readium.org>

⁸ <https://github.com/readium/readium/wiki/EPUB3-Feature-Matrix>

⁹ <http://www.vitalsource.com>

¹⁰ <http://www.digitalbookworld.com/2012/kobo-to-fully-support-epub-3-by-third-quarter-2013/>

It is not available on earlier versions of iOS or on other EPUB-compatible ebook readers. In January 2012, together with the 2.0 version of iBooks, which allows ebooks to include interactive diagrams, audios and videos, Apple also released the authoring tool iBooks Author (Sect. 3.2.2), which allows authors to intuitively design enhanced ebooks and self-publish them through the Apple iBookstore in a format with the extension “.ibooks”. The latest release of iBooks is version 3.0 (announced in October 2012), which introduces new templates, portrait-only books, and some other features.

Users using the iBooks reading application receive their content primarily from Apple’s iBookstore. The iBookstore delivers ebooks in the EPUB format (including Apple’s Fixed Layout EPUB) and .ibooks. As the iBookstore uses Apple’s FairPlay DRM system (see Sect. 6.2), an export of ebooks out of the iBooks application to other readers is not possible. However, users of the iBooks reading application can import EPUB and PDF ebooks from various other sources as long as they are not DRM protected. The iBookstore delivers EPUB content only to devices running at least Apple’s iOS 4; a download or reading of ebooks in non-Apple environments is not possible. The books available in the iBookstore come from many major publishers (Penguin, HarperCollins, Simon & Schuster, Macmillan, Hachette, Springer, and others) as well as other sources like Project Gutenberg¹¹, which provides access to thousands of free books, or Smashwords¹², which allows independent authors to self-publish.

3.2.1 Apple Fixed Layout EPUB

Three of the big ebook retailers (Amazon, Barnes & Noble and Apple) have developed their own and proprietary fixed-layout ebook formats. The Barnes & Nobles format is essentially an EPUB 2.0.1 format with some extensions. The page images used on the Nook reader of Barnes & Noble (software as well as physical device) are directly created from the incoming PDF files. Apple’s Fixed Layout EPUB (published in December 2010) is a descendant of EPUB 2.0.1 (published in September 2010) extended with some additional proprietary features. For example, the allowed page size is predefined and the text does not reflow with changing screen sizes and resolutions.

Publishers of children’s books were especially interested in Apple’s Fixed Layout EPUB as it offers features not available with the EPUB 2.0.1 standard. Apple designed its Fixed Layout format so that the presentation of ebooks is optimal for the Apple devices iPad, iPhone, and iPod Touch. Apple is able to ensure a proper presentation of graphic elements and illustrations in ebooks as they have full control over their reading devices running iBooks and do not need to support any non-iOS devices. There are only a few limitations of the format for publishers, for example, a maximal resolution for cover images, a maximal file size, a fixed size for videos, and constraints on the CSS parameters.

¹¹ <http://www.gutenberg.org/>

¹² <http://www.smashwords.com/>

Besides the fixed-layout option, the Apple Fixed Layout EPUB format also has some other interesting features like text-to-speech and scripting. The text-to-speech functionality (Apple denoted this functionality “Read Aloud”) is very similar to EPUB 3 (released ten months after Apple’s Fixed Layout EPUB) and realized by using Media Overlays (Sect. 3.1). Furthermore, in analogy to the upcoming EPUB 3 standard, Apple’s Fixed Layout EPUB allows the use of JavaScript. However, Adobe Flash animations are not possible as Apple does not support this software. In summary, Apple’s Fixed Layout EPUB offered publishers additional features ten months before the release of EPUB 3. With the release of EPUB 3, Apple’s Fixed Layout EPUB became obsolete as all of its features are covered by EPUB 3. Currently, it is not actively developed by Apple any more, Apple instead supports and uses EPUB as the main format for ebooks. Nevertheless, there are still publishers who mainly publish ebooks through the iBookstore and prefer Apple’s Fixed Layout EPUB over EPUB 3.

3.2.2 iBooks Author

In January 2012, Apple presented the ebook authoring application iBooks Author¹³, a tool aimed at authors and publishers interested in self-publishing. In October 2012, Apple launched a new version 2.0 with additional features like font embedding, rendering of mathematical equations, and higher interactivity. The application can only be used on computers with iOS 5 or later and is free of charge. The output of iBooks Author is a book in either PDF format or a proprietary Apple file format (extension .ibooks) which can only be published through Apple’s iBookstore. The .ibooks format is based on EPUB 3, but uses proprietary XML namespaces and CSS extensions [6, 5]. A publication of ebooks produced by iBooks Author in online stores or platforms different from Apple’s iBookstore is not possible. eBooks in the .ibooks format can only be viewed on iOS devices using the iBooks reading application. A direct import of EPUB ebooks into iBooks Author is neither possible nor necessary [18, 8], as authors that are interested in publishing EPUB books can directly upload their EPUB ebooks in the Apple iBookstore.

Technically, iBooks Author is an easy-to-use WYSIWYG editor for ebooks. Authors can directly edit text, colours, images, and charts. To create interactive elements, Apple introduced customizable widgets allowing authors to create features like image galleries, movies or audio files, multiple-choice questions, slideshows, 3D elements, separate scrolling sidebars, pop-overs, and general HTML5 widgets¹⁴.

In summary, Apple supports the open EPUB standard and with the iBooks reading application provides one of the best EPUB 3-compatible readers. Apple’s Fixed Layout EPUB was a temporarily used proprietary format which allowed authors to prepare fixed-layout ebooks before this feature was available in EPUB 3 more than 15 months later. In general, eBooks in the EPUB

¹³ <http://www.apple.com/de/ibooks-author>

¹⁴ <http://support.apple.com/kb/PH2789>

format can be easily imported into Apple's ecosystem and displayed on Apple devices. However, Apple established a closed ecosystem, as all ebooks once developed or distributed inside the Apple world can never leave the ecosystem (except as PDF) and cannot be displayed or read on non-Apple devices. The main instrument of Apple for creating a closed ecosystem is its DRM system FairPlay (see Sect. 6.2), which controls the usage of content on Apple devices and which does not allow an export of content out of the Apple world. Although Apple encourages authors to use the EPUB standard and uses the standard within its own ecosystem, the system is closed as ebooks can only be imported in the ecosystem, but are not allowed to leave the Apple world.

In addition, Apple established an incompatible format for the generation of content that should be distributed in its ecosystem. The authoring tool iBooks Author produces ebooks in the .ibooks format, which is incompatible with EPUB and can only be used and read inside the Apple ecosystem. The incompatibility between .ibooks (which can only be published through the iBookstore) and EPUB 3 is artificial and intended as it ensures that the authoring tool iBooks Author can only be used for ebooks that are sold through Apple's iBookstore. By using a non-standard variant of EPUB 3, Apple prevents authors using iBooks Author to create ebooks that are published on other platforms rather than the iBookstore.

3.3 Amazon's KF8 Format

In January 2012, Amazon released its new proprietary ebook format KF8. This XML format replaced the proprietary MOBI format, which was developed by the French company Mobipocket SA. Mobipocket SA was acquired by Amazon in 2005. The MOBI format (file extension .mobi or .prc) is based on the OEBPS format (Sect. 2) extended by JavaScript and Frames. For copyright-protected ebooks, Amazon uses the AZW format, which is a variant of the MOBI format with additional compression. The AZW format allows Amazon to apply a DRM scheme (see Sect. 6.2) and to restrict the use of an ebook to a particular device (identified by its device ID associated to an Amazon user account). DRM-free AZW files are just compressed MOBI files. The MOBI (as well as AZW) format allow authors to produce text-heavy books; the support of multimedia or interactivity features is not possible.

eBooks sold through Amazon's Kindle Store can be read either using the proprietary Kindle reading devices, the proprietary Kindle reading software which is available for various operating systems (including iOS), or directly in a web browser. The first Kindle reader was introduced in 2007; a newer DX line with a larger screen was introduced in 2009. Newer reading devices have additional features like keyboard (Kindle Keyboard), touch display (Kindle Paperwhite), or colour display (Kindle Fire). All Kindles (except the Kindle Fire, which was introduced in September 2011) use digital ink, which limits the available colours to black and white.

Amazon's reading devices and software can only display ebooks available in PDF, AZW (MOBI), or KF8. Other formats like EPUB or Apple's Fixed Layout EPUB cannot be displayed. In addition, Kindle's terms of use explicitly forbid transferring ebooks sold through Amazon to other non-Amazon devices. Due to the large economic success of Amazon, ebooks in AZW format are also available in other commercial and non-commercial ebook stores like Fictionwise (an electronic bookseller owned by Barnes & Noble), Project Gutenberg¹⁵, the World Public Library, and others.

Amazon started a self-publishing service named Kindle Direct Publishing in 2007. In the standard program, Amazon keeps about 65% of the revenues from ebook sales; the remaining revenue is for the author (and publisher). A newer program (named Kindle Direct Publishing Select Program) increases the royalties for the authors to 70% (which is similar to ebooks sold through Apple's iBookstore), however an author must remove his/her ebook from sales on all other websites, including their own website, for the first 90 days after publication. During this time period, Amazon has the exclusive right to distribute and sell the ebook.

Technically, the KF8 format supports HTML5 and CSS3. For downward compatibility, a KF8 file contains two formats: a MOBI file of the ebook and a data structure similar to EPUB. Detailed specifications of the KF8 format are not publicly available. KF8 files can be created using either KindleGen¹⁶ or a Plugin for Adobe InDesign¹⁷. The proprietary command line tool KindleGen is a converter which expects documents in HTML, XHTML, or EPUB format as input and converts them into KF8¹⁸. Analogously, the Plugin for Adobe InDesign allows a direct conversion of InDesign files to KF8. There are no other publicly available tools that allow authors to generate KF8 files.

In comparison to the previous MOBI format, the new KF8 format allows authors to include audio and video elements in an ebook by supporting the HTML5 elements <audio> and <video>. However, not all of Amazon's readers and reading applications support video. For example, movies can be played by the Kindle reading software for iOS but not by the Kindle reading software for Android or the different Kindle devices, including the Kindle Fire. All Kindle readers (except Kindle Fire) can only play audio files (if they have an earphone plug). Any kind of text-to-speech or read aloud functionality is not supported by KF8.

In general, KF8 supports many features of EPUB 2.0.1 and EPUB 3. With new guidelines published in February 2013 [3], Amazon aims for stronger EPUB 3 support: now, the structure of cover references and table of contents navigation (toc-nav-elements) follow the EPUB 3 specification and

¹⁵ <http://www.gutenberg.org/>

¹⁶ <http://www.amazon.com/gp/feature.html?ie=UTF8&docId=1000765211>

¹⁷ <http://www.amazon.com/gp/feature.html?ie=UTF8&docId=1000765271>

¹⁸ <http://wiki.mobileread.com/wiki/KindleGen>

are offered as an alternative to the KF8 syntax. However, KF8 still carries forward some HTML constructions that were de-standardized years ago, but it also extends the EPUB 3 format with some functions to support Amazon's proprietary fixed-layout option. To help authors to publish books through its Kindle Store, Amazon publishes a list of all HTML and CSS elements that are compatible with its KF8 format [1]. Like EPUB 3, KF8 supports CSS Media Queries, scalable vector graphics, and a fixed-layout option. As KF8 supports no JavaScript, HTML5 elements like `<canvas>` cannot be used. Also, MathML is not supported.

In summary, Amazon does not support the EPUB standard, but uses its own proprietary KF8 standard. KF8 files are generated by a proprietary converter which accepts EPUB files as input. However, Amazon introduced proprietary extensions and modifications making the two standards EPUB and KF8 incompatible. Like Apple, the Amazon world accepts EPUB files as input but does not allow users to export or transfer ebooks to other ecosystems. The Kindle readers, as well as the Kindle reading software, only display ebooks bought in the Amazon ebook store, and Amazon's Kindle Store delivers content only to Amazon reading devices and software. This makes Amazon's ecosystem closed as it allows no free exchange of books. Analogously to the Apple world, the main instruments for a closed ecosystem are the impossibility of exporting ebooks, the tight coupling between reading devices and store, and the DRM protection. Unlike Apple, Amazon also uses an incompatible ebook format, which strengthens the closeness of its ecosystem.

4 Feature Comparison

In the previous sections, the focus was on the description of the development of ebook formats up to EPUB 2.0.1, which for the first time integrated the standardization of ebook files for production with a standardization of ebooks for distribution to the end-user. In the latter case, issues such as compression had to be addressed. Moreover, the approaches to overcome identified shortcomings of EPUB 2/2.0.1 (2007/2010) have been introduced. These are primarily in the areas of interactivity and multimedia (in the direction of so-called enhanced ebooks), but also including, for example, the option to ‘switch off’ the reflow of text depending on the screen size or the resolution. The central strand of these efforts to overcome the restrictions of EPUB 2 is the further development of the standard in the form of EPUB 3 (2011/2012); however, as we have seen, there are also three proprietary attempts, namely KF8 (by Amazon), Fixed Layout EPUB and .ibooks (both by Apple). In the following section we will single out potentially important features publishers might like to see in their ebooks. We will then inspect the ebook formats in relation to their ability to realize these ebook features with the help of features of their respective formats. The selection as well as the structuring of the ebook features covered in the following is influenced by an application-oriented perspective, rather than one on the basis of the development history or the technological concept of the formats. Format features are clearly in focus; if it seems necessary or sensible, however, we will take reading device and reader software issues into account.

4.1 Core Features

Metadata

Metadata are data about data, in this case data about ebooks. Some of them are conveyed content-internally, i.e. as part of the ebook file (e.g. the author or the publisher of a book), or content-externally (e.g. the price or the order number). They are often used for administrative purposes (e.g. to enable the identification of knowledge resources by users or to specify copyright restrictions). In the case of EPUB 3 and EPUB 2, the Dublin Core Metadata Element Set (DCMES, in short: Dublin Core¹⁹) is supported for different kinds of metadata (the publication as a whole, but also, e.g., the videos in it). Dublin Core is a metadata standard that is also used in other contexts, especially library management; it specifies the information dimensions covered related to a content object. Certain metadata information of the 15 dimensions from Dublin Core, such as title, language, identifier (e.g. the ISBN) are defined as compulsory in EPUB, while others (e.g. author(s), publisher) are optional. In addition to this, EPUB 3 allows the definition of customized metadata information dimensions. Apart from Dublin Core, the metadata standards MARC (Library of Congress) and ONIX for Books (book trade),

¹⁹ <http://dublincore.org/documents/dces/>

among others, are supported; however, Dublin Core is the first choice as it offers the most comprehensive set of information dimensions.

With KF8, the situation is – due to the common line of descent of the formats (and the OPF file in particular) – similar. The difference is, that KF8 does not support the definition of additional customized information dimensions and has only a subset of 12 out of the 15 basic Dublin Core information dimensions; of those, only the title and the language information are compulsory. On the other hand, older versions of KF8 store the reference to the cover as an obligatory metadata item, which is different from the solution in other formats (see below).

The EPUB 2-descendent Fixed Layout EPUB by Apple shares the metadata arrangements with EPUB 2 – and therefore does not offer additional customized metadata information dimensions, either.

With ebooks produced using iBooks Author, metadata are attributed with the help of an input form on the authoring tool interface. Apart from this aspect, .ibooks files are, as we have seen, similar to EPUB 2 files and, for example, they also contain an OPF file.

Text Appearance and Fonts

Generally, the presentation of text (regarding, for example, font and font size) is controlled by the default settings of the reader software or the device, but also, alternatively, by the parameters defined by the actual user in a certain situation. EPUB 3 and KF8, however, allow the definition of default font, font size, character, word and line distances, etc., using CSS. These settings can be overwritten by explicit customer intervention if desired and provided for by the reader application. The font file (in one of the two font formats OTF and WOFF, a W3C font format recommendation) can be made a part of the ebook file and be referenced from the OPF file. The handling of type-related values set for particular titles, however, is not managed in a satisfactory manner by many reader applications/devices, up to the present day.

To prevent users from getting easy access to fonts supplied with ebook titles, EPUB 3 allows publishers to obfuscate fonts by encrypting parts of the font file. The algorithm encrypts the first 1040 bytes of the font file using a key that depends on the actual content. This mechanism allows the use of fonts only for specific content and prevents a further distribution of fonts. The mechanisms make the distribution of fonts more difficult, but they are comparatively easy to circumvent. This somewhat compromised protection is the reason, why many commercially traded fonts are not approved for the use in EPUB ebooks by the font copyright holders. With KF8, the encryption of the embedded fonts (in this case in OTF or TTF as font formats) is guaranteed by the binary encoding of the ebook file as a whole. For the support of international character sets, please consult Sect. 4.3.

Layout of Text

Reflowable Layout

Issues regarding font, font size, etc., have been dealt with in the previous subsection; this subsection covers issues concerning the distribution of text on a page. The type area (the area of the page without the top, bottom, right and left margins) can be defined globally in EPUB 3 using the CSS command “margin”. With KF8, it cannot be controlled globally and the top and bottom margins cannot be customized at all; the default print area on Amazon devices/reader applications, however, provides for rather big top and bottom margins by default.

With a reflowable text – a text that adapts to a particular screen concerning line length and line breaks – enforced page breaks generally do not make sense. With the help of the CSS command “page-break”, it can be achieved, e.g., to mark the beginning of a chapter. Moreover, reader applications generally insert a page break between the different HTML files that make up an ebook. Compared to KF8, EPUB 3 offers additional options to control the aesthetics of the displaying of text, e.g. by commands like “page-break-before” or “avoid” (keep paragraphs or headings together with subheadings). Moreover, there are commands that prevent “orphans” and “widows”; since the corresponding violation of typographic rules is considered unaesthetic, these commands enforce minimum numbers of lines as last and first paragraphs on pages, respectively. EPUB 3 also offers an automatic hyphenation which can be avoided by using the command “non-breaking-space”. The defects of KF8 mentioned are the reason why the composition in Kindle environments is often criticized by typographers. Other reasons for this are, that KF8 (as opposed to EPUB 3) does not enable language-dependent automatic syllable divisions and has justified composition as a default. KF8, however, allows at least “soft-hyphens”, the upfront tagging of potential breaks by the publisher.

Fixed Layout

The challenge of fixed-layout arrangements with digital books is that the look of the page (with text in a predefined typeface, in a predefined type size, etc.) on the one hand has to be stored, transferred and displayed much like an image. On the other hand, however, the text of the page should still be searchable (which, of course, is not the case for text as images). To achieve this, texts of the page has to be defined not only regarding the ASCII values of letters and numbers, but also regarding fixed pixel information. This is a challenge that in principle is, for example, analogically addressed by PDF as a data format.

The result for readers is similar with all fixed-layout formats – if he or she wants to enlarge certain sections on a page, this can only be achieved by zooming in and not by, for example, selecting a larger font and have the page line-wrapped accordingly. In the case of KF8, the zooming in is provided

with the help of pop-ups; the sections to be displayed in the pop-ups have to be identified by the publisher in advance. If provided for by reader applications on special devices, a fixed-layout double page spread is displayed rather than a single page. This can be triggered by certain conditions (Fixed Layout EPUB on iPads, controlled by an inclination sensor) or set globally (KF8, controlled by the publisher in advance, using the “landscape” command).

In fixed-layout contexts, it has to be defined explicitly, in which place on a page a letter, a word or an image are meant to be displayed. This description of the visual appearance of the page and its components can be realized with fixed pixel measurements in EPUB 3, whereas in KF8 percent measurements and the “em” measure, a traditional measure used by typographers (an alternative to points/pt), are used. An informal example for the former solution would be that an “A” in 10 pt Times New Roman is positioned at pixel location $X=200/y=400$: for the latter solution, that this letter is positioned at 30% of the horizontal and 40% of the vertical extension of the actual screen. It is obvious that the latter solution can cope with yet unknown screen sizes and resolutions in the future.

As has been mentioned above, the text of a page is also stored as symbolic text, on top of the visually oriented page description. This is necessary for searches and text-to-speech functionalities.

Differences between the various fixed-layout solutions are, for example, given by the fact that the fixed-layout option has to/can only be set globally in KF8, i.e. for the whole document. This is done as part of the global choice between the main genres the format is designed for, namely children’s books on the one hand and comics on the other. This is specified in the metadata. As opposed to this restriction, the fixed-layout option can be specified for single pages in EPUB 3, in the HTML header. Another difference is that, in KF8, the visually oriented page description is specified for double-page spreads, whereas this is done for single pages in the other formats.

With Apple’s Fixed Layout EPUB, the fixed-layout option is triggered through a corresponding file that is added to the META-INF folder. With KF8 and EPUB 3, it is done in the OPF folder, where all metadata are specified. Apple’s Fixed Layout EPUB can be seen as the functional predecessor of EPUB 3 with respect to this feature.

Fixed-layout issues are dealt with in detail in a recent BISG document²⁰.

Tables

Displaying tables in ebooks requires a trading off between appearance and readability of the table for readers on the one hand, and searchability and adaptability to displaying parameters like screen size and resolution on the other. A way that exclusively stresses the first in reflowable contexts is including tables as images. Including tables using HTML and CSS to be rendered

²⁰ http://www.bisg.org/docs/FieldGuideFXLBooks_version1.0.pdf

according to displaying parameters is a solution that provides searchability – it also allows the application of the text-to-speech function on them. In spite of being provided for in all formats in principle, this does not yield satisfying results in more complex cases (extensive use of colours, lines, wide columns, etc.). The reason for this is the current state of the development of the reader applications, which are not yet able to cope with some of the standard table constructs of HTML and CSS; evidence for such unsatisfying cases in different ecosystems is documented [10, Sect. 4.6]. As a fall-back solution, an HTML file can additionally be linked to an image. There are solutions for better results: these, however, require additional effort, either by using Media Queries and specifying explicitly different tables for different displaying parameters or, indeed, by using JavaScript. Both options, of course, depend on the support of Media Queries or JavaScript by the respective formats.

In fixed-layout contexts, problems regarding different displaying parameters do not apply, since the appearance of the table is explicitly defined.

Fundamental differences between the formats regarding the integration of tables as images or as HTML tables cannot be stated. There are, however, additional options in formats that allow Media Queries or JavaScript. JavaScript is supported by EPUB 3, .ibooks and to a lesser extent Apple's Fixed Layout EPUB.

Cover

EPUB 2 did not provide an explicit solution to include a cover in the sense of a cover image. It was possible, however, to reference a corresponding file from the metadata. This solution can still be used to cater for downward-compatibility in EPUB 3 and KF8 and is still the standard way it is done with Apple's Fixed Layout EPUB and .ibooks. The more elaborate EPUB 3 solution is to reference the cover image from the spine and include it in the manifest of the OPF file – as JPEG, PNG, GIF or SVG and without size restrictions. The reference in the spine specifies the position of the cover image relative to, for example, the table of contents or the cover page while reading the ebook. Interestingly, this solution is also provided for in the current version of KF8.

Navigation and Table of Contents

Independently from how reader applications present this feature to readers (i.e. by showing buttons for every chapter), the traditional format for tables of contents in EPUB 2 was an obligatory .ncx file. It is still the standard way it is done with Apple's Fixed Layout EPUB and .ibooks. This solution was replaced by a non-proprietary HTML5 solution using the <nav> element in EPUB 3. The units marked up with the help of the <nav> element do not have to be text, they can also be images. By using “page-list” together with the <nav> element referring to a traditional fixed page number is also

possible, as long as these page numbers are also specified in the text files themselves. Interestingly, this solution is also provided for in the current version of KF8. Before this last amendment, KF8 also used the .ncx file; in addition, the inclusion of an HTML table of contents page that is presented to the reader as the first page of the text is recommended – on top of the UI solution of the reader application on the basis of the .ncx file (as mentioned, e.g. with the help of buttons). Amazon’s idea behind this is to satisfy possible expectations by readers.

Images

Regarding the integration of images, the general solution has not changed from EPUB 2 to the formats in focus in this report: images are integrated using the HTML element ``. When using the fixed-layout option (for children’s books and comics) in KF8, however, the CSS command “background-image” must be used instead of the `` element. This is to prevent a collision with the KF8-specific region magnification function.

KF8 supports GIF, BMP, JPEG, non-transparent PNG and SVG as image formats. There are recommendations (resolution: rather low) and restrictions (file size, different for ebooks using the fixed-layout option and ones that do not). The adherence to these restrictions is taken care of automatically by the KindleGen production software; it is said to be not in the interest of users (download times).

.ibooks supports JPEG, PNG, and GIF, JPEG and PNG are explicitly recommended by Apple. There are also recommendations regarding file sizes and resolutions.

EPUB, including EPUB 3, supports GIF, JPEG, PNG and SVG as file formats and does not have file size restrictions as a format. However, there can of course be specific restrictions from the side of ebook shop providers also for EPUB.

4.2 Multimedia and Interactivity

Audio and Video

EPUB 3

The EPUB 3 specifications Content Documents 3.0²¹ and Media Overlays 3.0²² specify in which way audio and video files are integrated, played back and synchronized in an ebook. This is primarily done using the HTML5 elements `<audio>` and `<video>`. The audio and video formats any reader/device will be expected to be able to play back are listed as core media types in the Publications 3.0 specification²³, while others are optional.

²¹ <http://idpf.org/epub/30/spec/epub30-contentdocs.html>

²² <http://idpf.org/epub/30/spec/epub30-mediaoverlays.html>

²³ <http://idpf.org/epub/30/spec/epub30-publications.html#sec-core-media-types>

Apple's Fixed Layout EPUB

The integration of audio and video is the central improvement, which Apple introduced with its Fixed Layout EPUB format in 2010 (EPUB only first featured this in its EPUB 3 version from 2011, see above) [4]. At this time, such an integration was not possible with any other ebook format. To achieve this, Apple's Fixed Layout EPUB supported the HTML5 elements <audio> and <video> from the beginning. To guarantee an optimal playback of the multimedia content on mobile Apple devices, Apple specifies maximal file sizes, a selection of supported data formats as well as (for video) the size of the corresponding frame; according to that, audio can be integrated as m4a files (AAC, MP4), and video as m4v files (H.264 in an MPEG4 container) [4].

Apple .ibooks

The format produced by Apple's iBooks Author ebook authoring tool can – in spite of the format specification not being published – be said to be a variant of EPUB (2). The format details of the integration of audio and video files (which is possible) are not known – from the features presented on the authoring tool interface, it can be deduced, however, what .ibooks files must be able to express and what the iBooks reader software on Apple devices can play back: iBooks Author from version 2.0 on supports the integration of all multimedia data formats that are supported by Apple's QuickTime media player²⁴. The iBooks Author authoring tool optimizes audio and video regarding resolution etc., for the rendering on iPads.

Amazon KF8

Also with KF8, the integration of video and audio files in ebooks is generally possible – like in the other cases, the HTML5 elements <audio> and <video> are used for that. The playing back of audio and video content, however, is only enabled for the case of ebooks being read with the help of Amazon's Kindle iOS app for the mobile devices of Apple [2] – but not on Amazon devices. This is surprising, since at least some of Amazon's own reading devices are, in principle, able to play multimedia content (some only audio, the Kindle Fire also video).

Text-to-Speech (TTS) and the Synchronization of Text and Time-Based Media

Here, the text-to-speech related features as well as the ones related to the synchronization of (written) text with time-based media, especially audio (for the read aloud function) of the various ebook formats are discussed.

²⁴ <http://support.apple.com/kb/HT3775>

EPUB 3

With EPUB 3, these features are specified in the EPUB Content Documents 3.0²⁵ as well as the EPUB Media Overlays 3.0²⁶.

“EPUB 3 provides the following text-to-speech (TTS) facilities for controlling aspects of speech synthesis, such as pronunciation, prosody and voice characteristics: Pronunciation Lexicons using the W3C Pronunciation Lexicon Specification 1.0 (PLS)²⁷; the incorporation of SSML phonemes functionality directly into a EPUB Content Document, using the Speech Synthesis Markup Language (SSML) Version 1.0²⁸; CSS Speech Features from the CSS3 specification CSS Speech Module²⁹.”³⁰ This means, that, using EPUB 3, features of the text-to-speech output by a corresponding engine of a reader software can be parametrized (with respect to volume, male or female voice, modulation, etc.) by a set of standardized declarative files, one of them being CSS Speech, a part of CSS3. This feature enables, for example, “synthetic” audio books on the basis of written text in a very flexible manner.

The Media Overlays function enables the synchronization of audio (typically pre-recorded audio narration) with textual content, typically by highlighting (e.g. with the help of colour) the word just pronounced at any given moment. “In EPUB 3, Media Overlay Documents are created to describe the timing for the pre-recorded audio narration and how it relates to the EPUB Content Document markup. The file format for Media Overlays is defined as a subset of SMIL, a W3C recommendation for representing synchronized multimedia information in XML.”³¹ The narration “can be represented as a series of audio clips, each corresponding to part of the EPUB Content Document. A single audio clip, for example, typically represents a single phrase or paragraph, but infers no order relative to the other clips or to the text of a document. Media Overlays solve this problem of synchronization by tying the structured audio narration to its corresponding text (or other media) in the EPUB Content Document using SMIL markup. Media Overlays are, in fact, a simplified subset of SMIL 3.0 that allow the playback sequence of these clips to be defined.”³² For making the synchronization work, both the textual content and the (single) audio file, therefore, have to be tagged accordingly, using the mark-up provided by SMIL (a specialized XML language). Synchronizing textual information with other time-based media, e.g. with video subtitling, would generally follow the same principle, but is not yet supported by EPUB 3.

²⁵ <http://idpf.org/epub/30/spec/epub30-contentdocs.html>

²⁶ <http://idpf.org/epub/30/spec/epub30-mediaoverlays.html>

²⁷ <http://www.w3.org/TR/pronunciation-lexicon/>

²⁸ <http://www.w3.org/TR/speech-synthesis>

²⁹ <http://www.w3.org/TR/css3-speech/>

³⁰ http://idpf.org/EPUB/30/spec/EPUB_30-overview.html

³¹ <http://idpf.org/epub/30/spec/epub30-mediaoverlays.html>

³² <http://idpf.org/epub/30/spec/epub30-mediaoverlays.html>

Apple's Fixed Layout EPUB

Apple's Fixed Layout EPUB also offers the function to synchronize written text with audio, highlighting words in the text correspondingly. This function is called Read Aloud with Apple and is restricted to Fixed Layout EPUBs; reflowable EPUBs cannot make use of this feature, even if they are conformable with the iBookstore. "In read aloud books, an audio file using a narrator's voice can read the text on a page and the words can be highlighted as they are spoken. The reader can choose to have the pages turn automatically to keep the session flowing, or set them to turn manually. iBooks (Reader app) syncs text and audio using Media Overlays, an EPUB-specific subset of Synchronized Multimedia Integration Language (SMIL)." [4] This means, that Apple – as with the IDPF standard/EPUB 3 – uses SMIL to configure the synchronisation of pre-recorded audio with text. Fixed Layout EPUB also allows the integration of play, pause and stop controls into the reader (on Apple devices). When using those, the listener can control the playing back of the audio. A text-to-speech option, triggering and configuring the reading by a "synthetic" voice is not provided in Apple's Fixed Layout EPUB.

Apple .ibooks

With iBooks Author, text-to-speech or read aloud functions cannot be integrated; hence the question of how these functions are represented in the .ibooks data format is not applicable.

Amazon KF8

With KF8, neither a text-to-speech option nor the synchronization of audio with the corresponding highlighting of text is integrated; Media Overlays have not been adopted for KF8.

Interactivity and Animation

EPUB 3

With EPUB 3, there are two possibilities to realize native animations (as opposed to pre-recorded ones that are played back as videos) and interactive features. One has to keep in mind in any case, that animated content only makes sense on backlit devices like smartphones and tablets, since digital ink readers are not able to play this back due to hardware restrictions. The first possibility is using the CSS construct of transformations; using this, objects can be translated, etc. This is part of the core EPUB 3 specification and therefore any reader software/device conforming to EPUB 3 must be able to display corresponding content. Simple animations and other dynamic content items can be realized this way: objects get positioned 2- or 3-dimensionally and are made to move³³. The other functionally less restricted possibility is using JavaScript code; this, however, is only an optional element of EPUB 3 and therefore certain reader applications/devices might not be able to display it. The IDPF therefore recommends to use

³³ <http://www.w3.org/TR/css3-transforms/>

alternative options rather than JavaScript whenever possible. More advanced modes of animations interactivity can only be realized using JavaScript, however. So, JavaScript together with the HTML5 element `<aside>` enables better options, e.g. for marginalia or footnotes, such as pop-ups. Further JavaScript options include forms which can be used to establish a feedback channel from the reader to the publisher, or functions that make use of the geographical location of the reader, which is made available in the case of devices with a GPS sensor via an HTML5 element. Coming back to animations – in the sense of dynamic graphics – JavaScript code can be used for specifying objects and their movements on an HTML5 construct called canvas. This allows the replacement of proprietary technologies like Adobe Flash³⁴, which is, for example, not available on Apple devices. Since JavaScript is always executed in a so-called “sandbox”, however, there cannot be a sustainable exchange between the JavaScript application and other applications on the device. This makes it impossible to make use of contact details from the email application or to permanently store settings beyond a session in the EPUB container.

Apple’s Fixed Layout EPUB

Apple’s Fixed Layout EPUB – in spite of being based on EPUB 2.0.1., which does not support dynamic content – has supported JavaScript code from the beginning (2010). Only simple animations, e.g. animations with little complex code are possible this way, however.

Apple .ibooks

The authoring tool iBooks Author promises users that the integration of dynamic content is particularly easy – using the slogan “Interactivity in every book” to communicate this³⁵. Correspondingly, there are widgets for the production of pop-ups, interactive images with wheeling and zooming options, animated presentations, scrollable sidebars, multiple choice tests, etc. As mentioned above, the .ibooks format is not publicly documented and it is, therefore, not possible to formally describe the expressive power (and its limits) of .ibooks with respect to animations and interactivity in more detail. It is even possible with iBooks Author to integrate so-called HTML widgets (consisting of JavaScript and CSS code), which is essentially custom-made interactive content that can thus be integrated into .ibooks ebooks, supplementing functions that cannot be realized using the built-in options of the tool.

Amazon KF8

With KF8, neither JavaScript nor CSS transformations are supported. This means that interactive forms, animations, etc. cannot be realized for KF8 books. There are however a number of proprietary functions that, for instance, allow the display of magnified image areas as pop-ups (Magnification, Panel View [for comics etc.]).

³⁴ Flash is a software by Adobe. With its help, animations and animated graphics can be produced for integration into websites and other digital products.

³⁵ <http://www.apple.com/de/ibooks-author/gallery.html>

4.3 Globalization and Accessibility

Global Language Support

EPUB 3

EPUB 3 has been designed by the IDPF to be used worldwide, hence also across languages and writing systems. This can be illustrated by the fact that non-Latin writing systems/character sets (and their possibly differing directions of reading: from top to bottom, from right to left,...) can be integrated, e.g. for Japanese, Chinese or Arabic. As a generalization of a core feature, fonts of the writing systems mentioned, including special characters, can be included. Most of the features just mentioned are also available for EPUB 3 metadata, including file and directory names: this makes global distribution easier. The UTF-8 encoding for the Unicode character set is supported³⁶. In HTML5, referring to the ebook content, reading directions can be specified for the rendering engines of reader applications/devices. HTML5 – and hence EPUB 3 – also supports ruby annotations, a system for annotations for the pronunciation of Asian languages (but presupposes that the reader software/device is able to display it). Beyond this, CSS3 modules allow for design options regarding the typography, e.g. by vertically displaying text in a writing system that is usually displayed horizontally. It also allows for the control of syllable divisions and the representation of stress marks on top of letters. Finally, as mentioned already while presenting the text-to-speech functionality, pronunciation rules for any language can be specified using PLS and SSML; this includes interpreting ruby annotations (see above).

Apple's Fixed Layout EPUB, Apple .ibooks

With Apple's Fixed Layout EPUB – being based on EPUB 2 (which does not have global language support) – one has to assume that global language support as described above (for EPUB 3) is not supported. The same must be assumed for .ibooks.

KF8

With KF8, only Latin, Japanese (without ruby annotations, however), Chinese, and Korean characters are supported to a certain extent. As an option (the support is not guaranteed for all Kindle devices [2]), left-to-right writing systems can also be displayed vertically, if this is specified in the metadata accordingly. This does not apply for writing systems with a right-to-left reading direction, however.

Accessibility

The most striking accessibility-oriented feature for ebooks is the text-to-speech functionality, which we have described for EPUB 3 and Apple's Fixed Layout EPUB (Read Aloud, more restricted) above. Another feature of EPUB 3 are so-called fallbacks, which enable the specification of an

³⁶ <http://idpf.org/epub/30/spec/epub30-overview.html#sec-gls>

alternative media element in place of one that might not be received by the ebook user, be it as a consequence of a disability or in a certain situation (e.g. with background noise). The typical case is an explanation text instead of a video. In EPUB 3, there are HTML5 options to realize this, e.g. using an attribute within the <video> element.

4.4 Future Features

There are a number of items on the agenda list of the IDPF, concerning the further development of EPUB or its features. In the following text, we will mention the most striking examples.

Advanced/Hybrid Layouts

“The Advanced/Hybrid Layouts working group intends to publish a set of modular specifications that extends EPUB 3 functionality to better meet the full needs of the ecosystem with regards to user and context adaptation and reading of image-based publications such as comics and magazines.”³⁷ In future versions of EPUB, these specifications will, for example, allow to differentiate presentation specifications between different parts of publications, e.g., for the case of multilingual publications.

Dictionaries and Glossaries

In³⁸ some reader applications, dictionaries for use from other ebooks can be integrated. These can be consulted from all ebooks on the corresponding reader, not differentiating between them. The IDPF, however, sees the need for access to specific dictionaries, glossaries, etc. from certain books (e.g. children’s books, language learning books, scholarly books). Therefore, future versions of EPUB will be able to integrate dictionaries and glossaries specific to books; one among these can be selected as a preferred source of reference for a book by users.

Indexes

“Indexes are specialized navigational and supplemental information tools that offer readers an interaction with content that is enhanced, more powerful, and more specific than simple search. Users will expect to have indexes available in the EPUB 3 ecosystem and accessible as easily as search. Publishers of EPUB 3 content wish to make this data available to users, to allow them to explore book contents beyond what search results reveal.”³⁹ Index entries are links to portions of text; these links do not have to – but of course can – be a literal extract from the portion of text, but they are the result of editorial work and might, for example, consist of an hyperonym of one of the key concepts. Future versions of EPUB will be able to integrate such indexes, including for reverse use in the sense that index entries associated with a range of text can also be viewed.

³⁷ <http://idpf.org/charters/2012/layout/ahl.html>

³⁸ <http://idpf.org/charters/2012/dictionaries/>

³⁹ <http://idpf.org/charters/2012/indexes/>

Advanced Adaptive Layout

“This EPUB specification defines a model for template-based adaptive paginated layouts as an extension to CSS. The features described in the specification allow authors to describe precise page appearances that adapt to a wide range of device sizes and custom user settings. Its primary focus are interactive display environments in which the page size and user-defined font metrics are unknown at the time of document authoring and layout has to be done on the fly. This specification builds on CSS 2.1 and several CSS3 modules.”⁴⁰ This feature of future EPUB versions addresses the conflict of interests, that on the one hand certain types of books have a typical (and mostly also relevant: cf., for example, a cookbook) layout, some settings for which should not be disposable for adaptation by users to guarantee the reading experience or a recognition effect, respectively. On the other hand, there are different devices available with different screen sizes and resolutions – and of course reader preferences: font, type size, etc. – that should allow for adaptation. This feature defines a process in which content can flow dynamically into a set of linked containers based on page templates.

4.5 Summary of the Feature Comparison

Metadata

EPUB 3 has the most developed metadata options. While all other formats are restricted to a limited subset of the Dublin Core information dimensions, EPUB 3 also supports alternative metadata standards and allows customized metadata.

Text Appearance and Fonts and Layout of Text

With respect to options concerning the pre-specification of fonts, font sizes, etc., as well as the integration of special fonts for single ebooks, the formats in focus are very similar. Concerning the arrangement of text blocks on a page, EPUB 3 offers the most comprehensive set of controllable parameters. KF8 has limitations, e.g. concerning the specification of margins as well as of aesthetically motivated interventions like the aversion of so-called orphans and widows. Moreover, the fixed-layout option can only be set globally, i.e. for the whole document. With KF8, positions in the fixed-layout option can be specified using a percentage-oriented measure (as opposed to a pixel-position oriented one as used in EPUB 3), which gives it a higher degree of flexibility for future screens.

Tables

In all formats in focus, the integration of HTML/CSS tables is possible. However, the support by the reader applications to display tables nicely and correctly is on an unsatisfactory (and badly documented) level. An important additional option (JavaScript) to realize complex tables is given with EPUB 3 and .ibooks as well as – to a lesser extent – with Apple’s Fixed Layout EPUB.

⁴⁰ <http://idpf.org/epub/pgt/>

Cover

Regarding the integration of covers, EPUB 3 and KF8 allow a more flexible referencing of the cover file (relative, e.g., to the table of content or the first page of the book) from the spine rather than from the metadata. Independently, the latter solution is offered by all formats in focus, not least to ensure downward compatibility with older reader applications.

Navigation and Table of Contents

Using the HTML5 element <nav>, EPUB 3 and KF8 enable more flexible tables of contents, e.g. ones that have images rather than only text portions as active links to sections in the book or that are able to reference the fixed page numbers of the underlying printed book. Apple's Fixed Layout EPUB and .ibooks use the less advanced and EPUB-proprietary (rather than HTML standard based) .ncx file for tables of contents.

Images

With respect to the integration of images, the formats in focus are very similar; this is not least due to the fact that the option had already been part of EPUB 2. Current differences mainly refer to restrictions concerning file sizes.

Multimedia

All data formats reviewed can integrate multimedia content (audio and video), differentiated only by restrictions regarding which audio and video formats can be expected to be played back by the appertaining reader applications. KF8 is a special case in that audio and video can be integrated into the format as such; these, however, will not be played back on Kindle devices at all, but only on the iOS Kindle app on Apple devices.

Text-to-Speech

EPUB 3 allows text-to-speech, controllable to a large extent using standardized file formats, as well as the synchronization of, for example, text highlighting and pre-recorded narration. The latter synchronization is also supported by Apple's Fixed Layout EPUB; this format, however, does not support text-to-speech. KF8 and .ibooks do not offer any of these features.

Interactivity and Animation

EPUB 3 offers two fundamental options for dynamic content (dialogues, animations), namely one using CSS transform and one using – essentially unrestricted – JavaScript; JavaScript, however, is only an option in that it cannot be expected to be supported by every reader application. Apple's .ibooks format (as generated by iBooks Author) generally offers the same options as EPUB 3 in this area; some of them are presented as options on iBook Author's WYSIWYG interface, more complex ones can be integrated using HTML widgets (containing CSS and JavaScript code). Apple's Fixed Layout EPUB only supports simple JavaScript code. With KF8, generic

dynamic content is not supported; there is, however, a proprietary function that allows the magnification of image areas as pop-ups (e.g. for comics).

Global Language Support

EPUB 3 offers a wide range of options for internationalization from Unicode as character set (in UTF-8 encoding) via full flexibility regarding the reading direction to the configurability of the text-to-speech function regarding language-dependent pronunciation rules. With KF 8, only a few Asian languages are supported. Apple's Fixed Layout EPUB and Apple's .ibooks do not offer support beyond languages with Latin characters. Important features providing better access to ebooks for disabled people include the text-to-speech feature (EPUB 3 and – to a more restricted degree – Apple's Fixed Layout EPUB) and so-called fallbacks, which allow the specification of alternative media elements (e.g. a text alternative to a video); the latter are only provided for in EPUB 3.

Bottom Line of the Feature Comparison

Comparing the expressive power of the formats in focus, we have seen that these are either more or less equivalent (e.g. regarding images) or EPUB 3 realizes the more or less obvious superset of what is possible in the different formats (e.g. regarding the text-to-speech functionality or the full JavaScript support for interactivity). At the moment, there is one single feature that gives KF8 a slightly higher potential for future developments: its measurement for fixed positions on a screen in fixed-layout contexts is based on percentage information rather than on absolute pixel positions (as in EPUB 3).

5 Alternative Options

The general paradigm of the production and distribution of ebooks, including enhanced ebooks, we have looked at here is one in which a file that encodes the content of the ebook, including its hypertext structure, interactive features and multimedia, is downloaded by a customer and stored and viewed on his (typically mobile) device. A subtype of this paradigm is given by a set-up in which this file is not downloaded, but kept on a central server as part of the so-called cloud (and rendered from there). This file is declarative, i.e. it is not a program or an application, but it just describes the ebook with all its features; it is written in a special “language”, e.g. in EPUB 3 or KF8. This description is rendered into an actual ebook with the help of a reading application that runs on the mobile device and is able to handle this “language” or data format respectively, rendering what is on the lowest symbolic level of observation just a string of 0s and 1s into something that can be read as a book on a screen. Interoperability issues around this paradigm of production and distribution of ebooks just presented are the subject of this report. To roughly adumbrate the bigger picture, however, we would like to introduce two alternative options for realizing digital books; these are substantially different from the one just presented. The first of these alternatives are book apps and the second ebook streaming. Both get applied in actual products and projects, but as of now do not have the market significance of the declarative download-file-and-view paradigm.

5.1 Book Apps

App – for application – has become the common name for programs that are developed especially for smartphones and tablets. The distribution channels for these apps are the so called app stores of the various mobile operating/‘ecosystems’: iTunes for Apple’s iOS operating system, Google Play for Google’s Android operating system, etc. Mobile apps in this sense – procedural files that do not need reader software to be run, but include content as well as the reading/rendering application – can also be used to realize digital books, and multimedia interactive ones in particular. Typical cases for this are children’s books or ‘books’ with special features like exportable annotations. These cannot be realized in the interplay between a book as a declarative file (e.g. EPUB 3) on the one hand, and the corresponding reader application (over which the originator of the digital book does not have any control) on the other. There are three fundamental ways to produce (book) apps – as native apps, as web apps, or as hybrid apps. Native apps are programs, pieces of software, that only run on the operating system they are developed for, using native programming languages like Java (Android), Objective C (iOS), or .Net (Windows), respectively. To make a title available on various operating systems, it must be implemented separately for every single one.

A so-called web app is actually not an application – it is a declarative file, which uses the language elements of websites (HTML5, CSS, JavaScript) and therefore can be viewed using a web browser, e.g. Safari/Apple or Chrome/Google. This web browser is able to adapt the content to the respective display size and resolution. Web apps typically cannot be run in offline mode, as server-side interactive features cannot be made available. The third case is, when the declarative book content and the application being able to render it (not a web browser) are integrated in an app, a self-containing application; this is a logical requirement for getting distributed via an app store. Such a combination of website-like content with a proprietary native rendering app is called a hybrid app. As with native apps, this opens up the app stores as distribution channels to publishers. The advantage of hybrid apps with separated content modules compared to native apps, in which content and rendering are inextricably intertwined, is that they can be developed faster, easier and hence more economically using so-called app frameworks. Such a framework facilitates the methodical (parallel) development of hybrid apps for different operating systems. It offers interfaces which make it possible to address operating system specific functions in a uniform way. This makes it possible to develop the content only once per title (using HTML5, CSS, JavaScript), which then, using the app framework, can be made available for different operating systems without much effort. Remaining advantages of native apps compared to hybrid apps are mainly in the gaming sector, since complex graphic processing cannot be realized in a sufficiently effective manner using JavaScript (as opposed to Java proper).

When compared to ebooks in the sense of declarative files (EPUB or one of the proprietary formats) displayed on a reader application, book apps – be they native or hybrid apps – allow functions like communicating with other applications like mail, messaging or phone applications. The same is true for the export or the storing of annotations or for the recording of audio. Book apps are pretty common in the area of children’s books. It has to be remarked, however, that many of the functions (e.g. simple animations) used in such book apps are/will be possible also with EPUB 3. However, there are no reader applications on the market yet which can display all of these functions (as we have pointed out several times). For some of the advanced functions mentioned, book apps are therefore currently the only option.

5.2 eBook Streaming

Beyond legal considerations when an ebook download might be seen not as a purchase, but only as the use of a license (which is not the topic here), there is a further alternative option to realize ebooks. Rather than download ebook files and render them (or render them from a file in the cloud), it is also possible to stream ebook contents to corresponding viewing applications. This option – streaming not continually, but in a request-response cycle – is used in settings, where access to ebook contents is not granted for good, but only for a certain period of time, mostly in the context of

ebook lending or flat rate schemes. Such services are offered by libraries, but also by certain publishers, online bookstores and specialized aggregators. If not taken care of with special mechanisms (e.g. for reading during a flight), streamed ebooks can of course only be read if the device is online. Since the streaming arrangements of different ebook streaming services are different, they are not interoperable between them. Some of the ebook streaming viewing applications can, however, also view downloaded EPUB ebooks (from the traditional paradigm) and realize basic features with them.

6 Protection of Copyrighted Material

6.1 Overview

Many publishers and authors are interested in content protection as ebooks can easily be reproduced and distributed. Digital rights management (DRM) broadly refers to a set of policies, techniques and tools that guide the proper use of digital content [14]. Major functionalities of DRM systems are packaging of raw content into an appropriate form for easy distribution and tracking, protecting the content for tamper-proof transmission, protecting content from unauthorized use, and enabling specifications of suitable rights, which define the modes of content consumption. Probably the most relevant aspects for publishers and booksellers are that DRM systems allow them [14]

- to monitor the usage of content and ensure that they are in accordance with the rights of the users,
- to track payment and ensure they are in accordance with the usage of content, and
- to manage security and privacy issues appropriately.

We distinguish different types of mechanisms used by publishers and ebook distributors to protect copyrighted material:

1. honor system,
2. closed ecosystem,
3. digital watermarking, and
4. software-based protection using encryption.

Honor systems do not enforce protection by technical features, but the copyright owner asks users to respect his intellectual property. An example is the novel *The plant* published in 2000 by Stephen King. King did not apply any technical DRM measures, but published the novel in separate chapters, continuing with the next chapter only if a certain number of users pay for the chapters already published. With the publication of the last chapter, many illegal copies of the book became available, rapidly reducing the willingness of the readers to pay for the content. Thus, King stopped the project.

Digital content can also be protected by creating a closed ecosystem. A closed ecosystem does not allow or makes it at least difficult for users to export or distribute content. An example of a closed ecosystem is Apple's iTunes Store. Since 2009, all music titles sold through the iTunes Store are not protected by technical DRM measures. However, the ecosystem is closed as users can download or play content only using Apple devices or software (iTunes, iPhone, iPod, iPad, Apple TV). An export of content out of the Apple world is only possible by burning individual songs on a CD. Another instrument

for establishing closed ecosystems is the use of proprietary formats. For example, the .ibooks format produced by the Apple authoring tool iBooks Author is incompatible with the EPUB 3 standard and can only be accessed in Apple's ecosystem through the Apple iBookstore using Apple devices (see Sect. 3.2.2). Although no hard DRM measures are used on the ebook files, a free distribution of content is not possible as all non-Apple devices or software readers cannot read the format. Important for establishing an effective closed ecosystem is a tight coupling between a store, where content is sold, and devices or software, that display the content.

A specific type of DRM is digital watermarking. Watermarking does not allow a publisher or ebook distributor to ensure a set of policies but allow a posteriori the identification of users which do not follow the policies. Watermarking inserts user-specific or content-specific information into visible or invisible ebook data like cover page, figures, video, audio files, fonts, or text. Watermarking does not prevent the unauthorized distribution and use of ebooks, however, it gives the publisher or distributor the possibility to reconstruct unauthorized distribution. There are two general types of watermarking:

- Forensic watermarks are user-specific information embedded in a media file. The embedded information is only accessible if the user knows about it. Forensic watermarks are used by publishers or distributors to identify where the content file originates. Forensic watermarks should be robust against removal attacks and identify information about the copyright owner for the watermarked item. Usually, forensic watermarks are intended to track copies of the data, not to directly prevent the copying.
- Denial watermarks aim to protect content. Examples for audio formats are SACD and DVD Audio. Such systems combine watermarking with software protection (encryption). End-user devices or software readers search for a valid watermark in the content and forbid access to the content if the watermark is not found. The production of a valid watermark involves secrets (e.g. keys) unavailable to the public.

Software-based protection using encryption limits the use of content only to registered and authorized users. In a standard and representative DRM model, the content provider prepares the content in a format supported by the DRM system. Then, the digital content is encrypted and packaged for distribution. As discussed in the previous paragraph, the content provider may add digital watermarks to the file to allow the copyright owner to identify ownership of the files. Encrypted documents are not directly useful for consumers as they must be decrypted with a key corresponding to the encryption key. In a next step, the encrypted content, together with keys for decryption and usage policies (number of copies, pay-per-view, etc.), is sent to a clearinghouse. The consumer can now stream or download the protected material through the distributor or from another source. To be able to view the protected material, he must request a valid licence from

the clearinghouse. The clearinghouse verifies the user's identity, charges his account based on the content usage rules, generates a transaction report for the content provider, and delivers a decryption key that allows the user to access the content on his/her device [13]. A usage of content without the decryption key is not possible. To prohibit a usage of content by unauthorized users who get access to the decryption key, the decryption key usually allows decryption of content only on specific devices (identified by their serial ID) or for a specific user (identified by a user or account name). A decryption on other devices with a different ID or by other users with a different account name is not possible.

If the clearinghouse is different from the content provider, consumers can pass along received digital content to other people through super-distribution [13]. To utilize content, a recipient has to contact the clearinghouse and provide whatever information or payment is required for the license. However, in many closed ebook ecosystems the content provider is identical with the clearinghouse and a free exchange of books between consumers is not possible. For example, Apple's iBookstore or Amazon do not use an external clearinghouse and do not allow the transfer of ebooks from one customer to another. In addition, passing along content to a user outside the closed ecosystems is not offered and not intended.

6.2 Software-based DRM Schemes for eBooks

Closed ecosystems rely on a tight coupling between ebook store and reading devices. Additional instruments are incompatible formats and software-based protection using encryption and watermarking. In the following paragraphs, we give an overview about the current software-based DRM schemes. There are four different DRM schemes available. Three of them are proprietary (Amazon, Apple's FairPlay, and Adobe Digital Experience Protection Technology), whereas Marlin is an open standard developed by the Marlin Developer Community (MDC). Currently, the four different DRM schemes are non-interoperable. Thus, DRM-protected books cannot be exchanged between the different DRM systems and ecosystems, respectively.

Amazon DRM

The DRM system used by Amazon is based on a DRM scheme developed by Mobipocket. Amazon applies the DRM scheme to all ebooks delivered through its Kindle Store (usually in KF8 format). A publicly available specification of Amazon's DRM scheme is not available.

Technically, Amazon applies the DRM schemes to the AZW and KF8 format (see Sect. 3.3), where the AZW format is an encrypted MOBI format. For Kindle devices, Amazon directly encrypts the container format (MOBI). The Kindle software reader uses a different DRM scheme, which is stronger than the DRM scheme for the Kindle devices, as it uses additional keys for each ebook instead of only one key decrypting the content on a Kindle device.

The Amazon DRM ensures that DRM-protected ebooks can only be read on Kindle devices or Amazon's reading software (available for all major operating systems and devices) and non-Amazon ebooks cannot be read on any of Amazon's Kindle devices or reading software. Amazon uses the user ID to identify a user and only allows the usage of content acquired by the user. Amazon does not allow a permanent transfer of ebooks bought in the Amazon Kindle Store to another user or any non-Amazon device or reader. Since January 2011, users can transfer one book for a time period of two weeks to exactly one other Amazon user.

Apple FairPlay

Apple uses a DRM scheme named Apple FairPlay. Apple FairPlay is applied to all content that is sold through the iBookstore and built into Apple's standard multimedia software QuickTime, which is used on the iPhone, iPod, iPad and the software reader iBooks. Apple's FairPlay DRM is compatible with the formats sold through the iBookstore, namely EPUB, .ibooks, and Apple's Fixed Layout EPUB. Analogously to Amazon, all books distributed through the iBookstore can only be used on Apple devices and readers. However, in contrast to Amazon, Apple allows the import of EPUB and PDF files from non-Apple devices and readers.

FairPlay encrypts the files delivered to the customer and embeds digital watermarks for identification. Official specifications of the DRM mechanisms are not publicly available, however there are some technical reports [9, 16]. FairPlay allows an unlimited number of copies of an ebook on one specific Apple device and a simultaneous use of an ebook on a maximum of five authorized devices. Meanwhile, there are software solutions like calibre⁴¹ or Requiem⁴² available, which allow users to remove the DRM protection from books bought in the iBookstore. Of course, removing the DRM protection is against Apple's terms of use.

Adobe Digital Experience Protection Technology

Adobe offers a DRM system named Adobe Digital Experience Protection Technology (ADEPT) used by some booksellers and distributors for protecting mainly EPUB content. The DRM scheme can be applied to PDF, EPUB, and Flash. The DRM scheme can be read by Adobe Digital Edition, which is an ebook reader developed by Adobe, and some other third-party ebook readers. ADEPT is the most commonly used DRM scheme besides Amazon and Apple.

ADEPT allows users to exchange documents between up to six computers. Users are identified by their Adobe ID. A variant of ADEPT is used by Barnes & Noble for their reading device Nook and reading software. Supported formats in the ebook store of Barnes & Noble are PDF and EPUB. Analogously to Amazon, ADEPT allows the lending of a book for two weeks to another user.

⁴¹ <http://calibre-ebook.com/>; this tool also removes the Amazon DRM.

⁴² <http://www.ibooksdrmremoval.com/requiem/>

Marlin DRM

The Marlin Developer Community (MDC) developed an open DRM standard named Marlin⁴³. MDC started in October 2008 with five members: Intertrust, Panasonic, Philips, Samsung, and Sony. Currently, about 30 companies are members of MDC. The design goals of Marlin are interoperability and openness. Currently, Marlin is the only open DRM format for ebooks available.

The Marlin development groups provides a number of specifications and tools, including conformance test suites, reference implementations, and software development kits necessary to create DRM content distribution systems. Marlin allows a flexible and general-purpose rights management similar to Amazon, FairPlay, and ADEPT. Marlin emphasizes the interoperability between various ecosystems which would allow users to transfer ebooks from one ecosystem into another. Marlin can also be used for delivering EPUB files as well as proprietary formats.

Currently, Marlin is used by the educational ebook reseller Kno⁴⁴, which sells ebooks in EPUB format. Kno's reading application is available for Apple iOS, Windows and Android.

6.3 Discussion

Currently, the closed ecosystems established by Amazon and Apple are protected by the use of proprietary and non-interoperable DRM schemes. The features provided by Amazon DRM, Apple's FairPlay, and Adobe ADEPT are similar, however an exchange of books from one ecosystem into another is not possible. The open source DRM system Marlin aims for interoperability and openness, however, it is not used by major players in the ebook market. The IDPF, which was successful in establishing EPUB as a relevant and platform-independent ebook standard, has not yet developed any standards or recommendations for DRM schemes⁴⁵.

The decision of an ebook provider to use a specific ebook format is independent from the use of a specific DRM scheme. In principle, any existing DRM scheme can be applied to the ebook formats EPUB, KF8, as well as Apple's Fixed Layout EPUB and .ibooks. However, in practice, Apple as well as Amazon use proprietary DRM schemes to restrict exchange of ebooks and to bind users to their ebook store.

Although Marlin is an alternative that would allow for an interoperability of DRM-protected ebooks, a free exchange of ebooks between different platforms is unlikely. For interoperability, the different ecosystems must allow users to import and export ebooks while still enforcing the DRM

⁴³ <http://www.marlin-community.com/>

⁴⁴ <http://www.kno.com/>

⁴⁵ compare <http://idpf.org/epub-content-protection-rfp> and <http://idpf.org/epub-content-protection>

restrictions. From a technical perspective this is possible, however, the ecosystem owner must accept books that are sold outside its ecosystem and enforce usage restrictions that have been defined by a different ecosystem. From the business perspective of the major players in the ebook market, this is not attractive. Instead, they use incompatible DRM schemes to prohibit the free exchange of ebooks and to bind users to their own ecosystem.

7 Conclusions

A free choice on the part of customers between different ebook stores and retailers is only possible if the ebook formats used are interoperable and the DRM mechanisms allow an easy exchange of files. With these criteria in mind, this report studies the interoperability of the major ebook formats – namely EPUB, KF8 (Amazon), Fixed Layout EPUB (Apple) – and .ibooks (Apple) and the interoperability of the DRM mechanisms used by the major retailers. From a format perspective, we answer the question whether the use of the open standard EPUB would allow publishers and authors to cover the superset of all functionalities of the proprietary formats KF8, Apple’s Fixed Layout EPUB, and .ibooks. From a DRM perspective, we examine what can be said concerning the possible protection of copyrighted material on the one hand and the functions of DRM to close ecosystems. The interesting question is which DRM schemes allow interoperability between ebook ecosystems. Both interoperable formats and interoperable DRM mechanisms are a prerequisite for customers to have a free choice.

Consequently, the document starts with a historical overview of the development of the open EPUB standard. This is followed in Sect. 3 by a detailed level description of the major formats: EPUB 3, Apple’s Fixed Layout EPUB and .ibooks, and KF8. Sect. 4 changes the perspective and compares the features provided by the different formats from the perspective of publishers who want to see certain features in their content. This section looks at core features, multimedia and interactivity, as well as globalisation and accessibility. Sect. 5 discusses alternative options, e.g. where ebook content is not rendered using a dedicated reader software, but content and viewer are packaged together as an ebook app. Sect. 6 compares the existing ebook DRM schemes; interoperable DRM systems are the second prerequisite of interoperability between different ebook ecosystems.

The main findings of this report are:

- With the use of EPUB 3, ebook format interoperability is possible between different ebook ecosystems. EPUB 3 is not only the format with the highest expressive power, but it includes the superset of all features of KF8, Fixed Layout EPUB, and .ibooks. This result is not surprising as KF8, Apple’s Fixed Layout EPUB, and .ibooks are descendants of earlier EPUB standards using the same or similar data structures.
- Instruments for building up closed ebook ecosystems are a tight coupling between reader devices and applications on the one hand and the store on the other, the impossibility of exporting ebooks, and restrictive DRM protection. The ebook retailer Apple supports the open EPUB standard and provides with the iBooks reader application one of the best EPUB 3 reader applications. However, Apple established a closed ecosystem, as all ebooks created or distributed inside the Apple world are not allowed to leave the ecosystem and cannot be transferred to non-Apple devices. Apple’s principal means of creating this closed ecosystem is the Apple

FairPlay DRM, which controls the usage of content on Apple devices. Thus, ebooks can only be imported into the ecosystem, but are not allowed to leave it.

- Amazon has also built up a closed ecosystem. Analogously to Apple, it does not allow users to export or transfer ebooks to other ecosystems or users. The Kindle reader devices and reader applications only display ebooks bought in the Amazon ebook store, and Amazon's Kindle Store delivers content only to Amazon reader devices and applications. Analogously to Apple, the instruments for achieving a closed ecosystem are the impossibility of exporting ebooks, the tight coupling between reader devices/applications and the store, and DRM protection. Differently from Apple, Amazon does not even support the EPUB standard, but uses its own proprietary and non-interoperable KF8 format. The use of a non-interoperable format strengthens the closeness of its ecosystem as it makes even non-DRM protected KF8 files unusable outside the Amazon ecosystem.

There is little official or publicly available documentation regarding the formats KF8, Apple Fixed Layout EPUB, and .ibooks. Even on request, Apple as well as Amazon did not provide any further technical documentation concerning the formats. Neither Apple nor Amazon commented our results, in spite of explicitly being asked by us to do so. In the absence of documentation and as a result of DRM protection, national libraries and other institutions that preserve cultural heritage do not store ebooks in proprietary formats. For example, the German National Library only archives ebooks in EPUB and PDF format.

In summary, we find that there are no technical or functional reasons not to use EPUB 3 as the interoperable ebook standard. Instead, Amazon and Apple use, propagate, and develop their proprietary formats mainly for market-strategic reasons (and possibly downward compatibility). A short-term obstacle to widespread use is the non-availability of fully EPUB 3-compatible reading applications. This problem, however, should be resolved at the end of 2013 when fully EPUB 3-compatible reader applications are scheduled to be available (e.g. Kobo, Azardi, or Apple iBooks reader).

However, a widespread use of EPUB 3 will only lead to interoperable ebook ecosystems, if the currently closed ecosystems become open beyond issues of data formats. Open ecosystems would allow users to import and export ebooks to and from other reader devices or reader applications. Such an exchange of ebooks between different systems and users makes it necessary to also exchange information about the DRM schemes between the different ecosystems. From a technical perspective, this is possible as the DRM features provided by the existing proprietary DRM schemes are similar and there even exists an open source DRM system (Marlin) aiming for interoperability and openness. However, the current business models of the main players in the ebook market aiming at lock-in effects for the customer do not fit with open ecosystems. A prominent example is Apple, which actively

supports the EPUB 3 standard and uses it for some of its ebook distribution, but keeps its ecosystem closed by the use of a DRM system which restricts the exchange of files, including of course ebooks. To reach true interoperability in the ebook market, the major retailers must agree on interoperable ebook formats **and** interoperable DRM schemes.

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This is a threat to the qualified European book distribution infrastructure and hence the European book culture, since subscribers to one of these ebook ecosystems cannot buy future ebooks from privately owned community-located bricks & mortar booksellers engaging in ebook retailing. This view is completely in line with the Digital Agenda of the European Commission calling in Pillar II for “an effective interoperability between IT products and services to build a truly digital society. Europe must ensure that new IT devices, applications, data repositories and services interact seamlessly anywhere – just like the Internet.”

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